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Occupational disparities in upper limb disorders: the Pays de la Loire study

Why are manual workers at high risk of upper limb disorders? The role of physical work factors in a random sample of workers in France (the Pays de la Loire study).

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Abbreviations:
INSERM: Institut National de la Santé et de la Recherche Médicale
InVS : Institut National de Veille Sanitaire0
PR: Prevalence Ratio
95% CI: 95% Confidence Interval

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ABSTRACT

We investigated occupational disparities in the risk of upper limb musculoskeletal disorders in a random sample of 2 656 French workers (age 20-59) participating in a study on the prevalence of work-related upper limb disorders, launched by the National Institute of Health Surveillance. Prevalence ratios (PR) of physician-diagnosed musculoskeletal disorders of the shoulder, elbow, wrist and hand (any of six leading disorders, rotator cuff syndrome, carpal tunnel syndrome) in manual vs. non-manual workers were calculated using Cox regression models with a constant time of follow-up and robust variance. 11% of men and 15% of women were diagnosed with an upper limb disorder. The risk was especially high in manual workers (PRs: 1.44 to 2.10). Physical work factors accounted for over 50% of occupational disparities overall, 62 (men) to 67% (women) for rotator cuff syndrome, and 96% (women) for carpal tunnel syndrome. We calculated that under lower levels of physical work exposures, up to 31% of cases among manual workers could have prevented. In working men and women, upper limb musculoskeletal disorders are frequent. Physical work exposures, such as repetitive and forceful movements, are an important source of risk, particularly among manual workers.

Work-related musculoskeletal disorders of the upper limb are among the leading causes of morbidity and work disability in industrial countries. In the European Union, 17 to 30 percent of industry workers are affected and treatment and lost productivity cost billions of euros each year (from 0.5 to 2 percent of the Gross National Product)(1). Prevalence rates are generally two times higher among manual workers than in other occupational groups. Although there is compelling evidence that physical work exposures contribute to the risk of upper limb musculoskeletal disorders(2), no previous study has addressed the question of how much of the disparity between manual workers and other occupational groups is attributable to differences in work exposures. We studied upper limb disorders among 2656 French workers, randomly surveyed at the time of a regularly scheduled occupational health examination.

MATERIALS AND METHODS

Study population

This investigation is based on data collected as by a surveillance study of work-related upper limb musculoskeletal disorders, launched by France's National Institute for Health Surveillance and set up in the Pays de la Loire region (Loire Valley district, West-Central France, population 3 220 000). Data were collected through a network of occupational physicians. In France, occupational physicians undergo a specialized 4-year residency program, during which they receive specialized occupational hygiene training. Their tasks include monitoring work exposures and performing annual health examinations, which are mandatory for all workers. Each of the 7000 currently-practicing occupational physicians simultaneously works across multiple companies and economic activities of the private sector, which employs about 70% of France's 25 million labor force (the self-employed, civil servants, and public sector employees are in principle covered by specific occupational medicine arrangements) (3).

460 occupational physicians practice in the Pays de la Loire region. Each oversees the health of 1400-1700 (for those working part-time) to 2800-3200 workers (for those working full-time). 80 physicians agreed to participate in this surveillance study, and were trained by the investigators (YR assisted by a study coordinator) to perform a standardized physical examination, based on an international protocol for the evaluation of work-related upper limb musculoskeletal disorders (SALTSA)(4). They were asked to include workers in the study from January 1st to September 30th 2002 and from May 1st to October 30th, 2003. First, with the investigators' assistance, each physician sampled 15 or 30 half-days of consultation (depending on whether he/she worked part-time or full-time). Next, per half-day of

consultation, each physician randomly selected 1 out of 10 workers undergoing a regularly-scheduled annual health examination. The study population comprised 2685 men and women aged 20-59 (mean 20.7, sd 8.7 per physician). This analysis was based on 1549 male and 1107 female participants with complete data. Participants worked primarily in manufacturing (33 percent) trade (14 percent) and real estate activities (14 percent), followed by public administration (9 percent), health (7 percent), transport (6 percent), construction (6 percent), community services (3 percent), financial intermediation (3 percent), hotels and restaurants (2 percent), agriculture (2 percent), education (1 percent)(5).

Participating physicians were representative, in terms of work-time, geography, and economic sectors covered, of the region's occupational physicians. Less than 10 percent of selected workers failed to participate (no shows, refusals) and between 2002 and 2003, no significant variation in workers' characteristics or in the prevalence of upper limb disorders was observed. Overall, the final sample was representative of the salaried workforce in the Pays de la Loire region and characteristic of France(6).

Measures

Study procedures included a self-administered questionnaire followed by a medical examination. The questionnaire contained validated questions on physical work exposures (Table 1) and musculoskeletal symptoms(4), as well as items on age (18-29, 30-39, 40-49, 50-59), obesity (<30 kg/m²/ >=30kg/m²), and occupational grade (coded according to France's national job classification: managers/members of intellectual professions, professionals/technicians, clerks, and manual workers (ex. painters, assemblers, mechanics, machine operators)(7)). The questionnaire was checked for completeness by the physician. Concurrent diabetes, thyroid disease, arthritis and pregnancy were reported to the physician.

Participants with pain in the neck, shoulder/arm, elbow, hand/wrist, or fingers in the preceding 12 months underwent a standardized localized physical examination(4). The physician followed a standardized diagnostic diagram to diagnose any of 6 principal upper limb disorders. Those who reported pain at the time of the examination or during at least 4 days in the preceding week, and whose physical examination revealed the presence of physical abnormalities were considered as cases. The physical examination allowed to establish six diagnoses: rotator cuff syndrome-ICD10 M75.1, 75.2, epicondylitis-ICD10 M77.0, 77.1, cubital tunnel syndrome-ICD10-G56.2 , extensor/flexor tendonitis/tenosynovitis ICD10-M70.0, 70.8, de Quervain's disease ICD10-G65.4, and carpal tunnel syndrome ICD10-G56.0(8). We used three study outcomes: any of the 6 principal upper limb disorders, and the two most frequent diagnoses: rotator cuff syndrome and carpal tunnel syndrome.

Statistical analysis

Prevalence ratios (PR) in manual workers, compared to the nonmanual, were calculated using Cox regression models with a constant time of follow-up and robust variance(9). Model 1 was adjusted for age, Model 2 additionally included individual risk factors of upper limb disorders (obesity, concurrent diabetes, thyroid disease and arthritis). Next, we added repetitive movements at work (Model 3) and force exertion (Model 4). For rotator cuff syndrome, subsequent models included work postures associated with shoulder disorders (arms above shoulders, hands behind trunk, arms away from the body); for carpal tunnel syndrome, models included risk factors of wrist/hand disorders (use of vibrating hand tools, wrist flexion). Our final models included all the above-specified personal and physical work factors. We found no significant interactions among work exposures.

The contribution of each work exposure to manual workers' excess risk was calculated as follows: percent = $[(PR_{\text{adjusted for personal factors}} - PR_{\text{adjusted for personal factors+work exp}})/ (PR_{\text{adjusted for personal factors}}-1)]*100$. Additionally, from our statistical models, we estimated the number of cases that could have been prevented, had levels of physical exposures been lower.

All analyses were conducted separately for men and women, using the SAS statistical package software(10).

The Pays de la Loire study received the approval of France's national ethics committee.

RESULTS

Of the 1549 men and 1107 women in our study population, 175 and 167 were clinically-diagnosed with an upper limb disorder (Table 2, prevalence rates: 11 and 15 percent). Leading diagnoses were rotator cuff syndrome (men n=105, women n=99) and carpal tunnel syndrome (men n=35, women n=44). 19 percent of men and 26 percent of women reported a history of upper limb disorders (16 percent and 20 percent reported past but not current disease). Male manual workers were somewhat younger than their nonmanual counterparts ($p<0.0001$); female manual workers, to the contrary, tended to be older than women in other occupational groups ($p=0.0826$) and also most likely to be obese ($p<0.0001$). The frequency and intensity of physical work exposures was systematically highest among manual workers; repetitive movements were especially frequent among women, forceful movements among men. Prevalence rates of upper limb disorders were systematically higher in manual than in nonmanual workers. Additionally, among women, manual workers also

reported more past disease (32.5 compared with 19.9 percent among nonmanual workers, p=<0.0001). As expected, exposure to physical work factors was associated with the risk of upper limb disorders (not shown).

Any of the 6 principal upper limb disorders

Adjusting for age, manual workers were 1.70 (men) to 1.89 (women) times more likely to be diagnosed with any of the six principal upper limb disorders than nonmanual workers (Table 3). Among men, 31 percent of this excess risk was related to repetitive movements at work, 28 percent to forceful movements. Among women, these work exposures explained 51 and 8 percent. Studied simultaneously, repetitive and forceful movements accounted for 52 percent of the excess risk among male manual workers', 57 percent among women (fully adjusted PRs: men: 1.32, 95 % CI 0.95-1.84; women: 1.39, 95% CI 1.02-1.89).

Rotator cuff syndrome

Compared to the nonmanual, manual workers were at high risk of rotator cuff syndrome (age-adjusted PR: 2.08 for men, 1.95 for women; Table 4). Repetitive movements, forceful movements (men only), and work postures that involved holding at least one arm above the shoulders or away from the body (women only), explained 2 to 56 percent of this disparity in risk. Adjusting for all physical work exposures, the manual-nonmanual risk ratio decreased by 67 percent among men and 62 percent among women (fully-adjusted PRs 1.35; 95% CI 0.86-2.12 and 1.34; 95% CI 0.88-2.03). Our results were robust when exposures with a small contribution to manual workers' risk (reaching behind the trunk and forceful movements among women) were excluded from the analysis (fully-adjusted PRs associated with manual work, respectively: 1.47; 95% CI 0.94-2.32 for men, and 1.29; 95% CI 0.85-1.93 for women).

Carpal tunnel syndrome

For carpal tunnel syndrome, the age-adjusted manual-nonmanual risk ratio was 1.44 and non significant for men, and 2.10 for women (Table 5). Among women, physical work exposures largely accounted for this disparity in risk (repetitive movements: 70 percent, the use of vibrating hand tools: 23 percent, extreme wrist flexion: 50 percent). Studied jointly, physical work factors explained 96 percent of female manual workers' excess risk (fully-adjusted PR 1.04, 95 % CI 0.51-2.11).

Preventable cases of upper limb disorders

As shown in Table 6, among manual workers, under lower levels of exposure to physical constraints, the number of cases of upper limb disorders could have been 23.8 percent (men) to 31.4 percent (women) lower. In 2004, 6 127 000 French men and women worked in a manual job(11), and assuming prevalence rates of 15% in men and 11% in women, about 720 000 probably suffered from upper limb disorders. Based on our estimates of the preventable number of cases, up to 197 000 cases could have been prevented, had levels of physical work exposures been lower.

DISCUSSION

Main findings

In our study, 11 percent of men and 15 percent of women suffered from a clinically-diagnosed upper limb musculoskeletal disorder. Prevalence rates were systematically highest among manual workers. Among men, occupational disparities were greatest for rotator cuff syndrome, among women for carpal tunnel syndrome. Over 50 percent of disparities were explained by physical work exposures, and particularly repetitive movements at work. Forceful movements played a key role among men. Upper limb musculoskeletal disorders are an important public health problem, and physical work factors appear as a key source of risk and occupational disparities.

Study limitations

Our study was cross-sectional and, in principle, the associations observed may be spurious(12). Reassuringly, the relationship between biomechanical work exposures and upper limb disorders is biologically plausible and has been shown in prospective studies (13-17). Additionally, under exposure to physical work factors, latency periods for upper limb musculoskeletal disorders of the type we studied can be as short as several weeks (18;19). In our study population, 87 percent of men and women worked in the same job for over a year, and therefore probably exposed to the level of physical work constraints reported at the time of the study. Thus, we believe that prevalent disorders were associated with occupational exposures on the most recent job. Advantages of a cross-sectional design are that we were able to collect detailed self-reported exposure data and clinical outcome measures in a large sample of the working population.

A potential source of bias is occupational physicians' low participation rate (17 percent). However, because in France occupational health visits are mandatory and

occupational physicians work across multiple companies and work sectors(3), participating physicians were representative of those practicing in the region, in terms of work-time, geography and economic sectors covered. Workers included in the study were characteristic of the region's workforce in terms of geography, economic sector and occupation. We found no evidence that workers' characteristics or the prevalence of upper limb disorders varied between the two periods of data collection (2002 and 2003). Although the likelihood of diagnosing upper limb disorders may have varied across participating physicians, given their large number (n=80), on average, inter-physician variability was probably low. Physicians who agreed to participate may have been particularly concerned about upper-limb musculoskeletal disorders among workers under their surveillance, but all followed a standardized diagnostic protocol and the prevalence of upper limb disorders is comparable to previous general population studies (20). Hence, we believe that there was no systematic bias neither in the selection of participating physicians and workers, nor in the diagnosis of upper limb disorders. Thus, the prevalence rates we report are applicable to the general working population.

Workers who experience pain may overrate their physical work exposures, and to limit potential bias, we used standardized instruments for assessment of exposures and disease(4). Exposure misclassification, if it did occur, could lead to erroneous estimations of the effects of work factors, and it is reassuring that the relative risks we report (approximately 2 for repetitive movements for men and women and 1.5 for forceful movements for men) are consistent with previously published international estimates (2.3-8.8 for repetitive movements, 1.8-9.0 for forceful movements)(2). More broadly, workers' evaluations of physical exposures are probably accurate(21), and according to a recent National Academy of Science report on work-related musculoskeletal disorders, simple self-reported measures, such as the ones we used, concord with direct observations(2).

As other investigations conducted in occupational settings, our study was subject to the healthy worker effect and did not include individuals who were not in the labor force due to musculoskeletal disease. However, the prevalence of upper limb disorders is generally higher among employed men and women than in the general population (e.g. 4.5 and 6.1 percent for physician-diagnosed shoulder tendonitis and 4.7 and 7.9 percent for discrete hand and wrist disorders in a British study(22;23), 2.8 and 4.6 percent for clinically-certain carpal tunnel syndrome in Sweden(24)), highlighting the critical role of work as a source of risk.

Physical work exposures and occupational disparities in the risk of upper limb disorders

In our study, the risk of upper limb disorders was 1.44 to 2.10 times higher among manual workers than among the nonmanual. Over 50 percent of this disparity was related to work gestures that are repetitive, forceful, or constraining, and which constitute known risk factors of shoulder, elbow, wrist or hand disorders(16;25-28). While the biophysiological mechanisms involved have not been fully elucidated, physical exposures that exceed the internal tolerance of soft tissues can lead to muscle/tendon injury, which becomes manifest as inflammation (e.g. tendonitis) and favors nerve damage or entrapment (ex. carpal tunnel syndrome). These in turn result in pain, neurological symptoms, and functional impairment(2;29).

Other important risk factors of upper limb disorders include age, obesity, diabetes, thyroid disease and arthritis, which we systematically controlled for in our analyses(30). Three participants were pregnant at the time of the study, and excluding them would not have modified our findings. We had no information on recreational activities (e.g. sports), women's hormonal treatment and menopause status(2;31), but there is no indication that these potential risk factors are more frequent among manual workers and contribute to disparities in upper limb disorders. Psychosocial factors, both work-related (e.g. job stress, job satisfaction, social support from coworkers) and personal (e.g. symptoms of depression) have also been associated with upper limb disorders(32). Yet, with the exception of neck problems, which we did not study, their effects are thought to be predominantly mediated by physical exposures(33;34). Still, personal and organizational factors probably influence the frequency and intensity of biomechanical exposures, indirectly shaping the risk of musculoskeletal disorders at the individual and population levels.

Our findings indicate that reducing exposures to physical risk factors could decrease the prevalence of upper limb disorders among manual workers. After adjustment for all other risk factors, our model suggested that decreases in forceful and repetitive movements could lead to reductions in the number of cases of up to one third.

Conclusion

Manual workers are at high risk of upper limb disorders, which are a leading cause of morbidity and disability. Lowering requirements for forceful and repetitive work gestures could lower the prevalence of these disorders and reduce occupational disparities in this area.

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- **Main messages**
- Musculoskeletal disorders of the hand, wrist, elbow, arm and shoulder are frequent in the working population (prevalence rates of 11% in men, 15% in women).
- Compared to the non-manual, manual workers are systematically at elevated risk of upper limb disorders (Prevalence Ratios ranging from 1.44 to 2.10).
- Physical work exposures, and particularly repetitive and forceful gestures, account for over 50% of occupational disparities in upper limb disorders.

- **Policy implications**
- Reducing physical exposures at work could decrease the prevalence of upper limb disorders in the working population, particularly among manual workers (up to 23.8 percent decrease in the number of cases observed in men, up to 31.4 percent decrease in women.

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Table 1. Description of physical work exposures (SALTSA protocol).

Occupational risk factors for multiple disorders of the shoulder, elbow, arm, wrist, hand	
Repetitive movements (same action > 2 times per minute >= 4 hours/day)	No (Level 0) Yes, with an hourly 10 minute break (Level 1) Yes, without an hourly 10 minute break (Level 2)
Forceful movements (manipulating loads of > 4 kg)	Never (Level 0); <2hrs/day (Level 1); >=2hrs/day (Level 2)
Occupational risk factors for disorders of the shoulder	
Holding one or both arms above the shoulders	Never; <2hrs/day; >=2hrs/day
Reaching behind the trunk with one or both hands	Never; <2hrs/day; >=2hrs/day
Holding one or both arms away from the body	Never; <2hrs/day; >=2hrs/day
Occupational risk factors for disorders of the wrist and hand	
Use of vibrating hand tools	<2hrs/day; >=2hrs/day
Wrist flexion	<2hrs/day, >=2hrs/day

Table 2 Characteristics of the Pays de la Loire study population (%, p-value comparing manual vs. non-manual workers)).

	Men n=1549			Women n=1107		
	Non-manual occupation n=678	Manual occupation n=871	p-value	Non-manual occupation n=818	Manual occupation n=289	p-value
Age: 18-29	18.6	28.4		24.2	22.8	
30-39	31.9	39.4	<0.0001	29.5	22.8	0.0826
40-49	31.7	25.1		30.4	37.0	
50-59	17.8	17.1		15.9	17.4	
Body mass index: <30 kg/m²	92.1	91.1	0.4965	94.5	85.1	<0.0001
>=30 kg/m²	7.9	8.9		5.5	14.9	
Diabetes: No	98.1	98.2	0.9217	98.8	98.6	0.8386
Yes	1.9	1.8		1.2	1.4	
Thyroid disease: No	97.2	99.0	0.0098	93.0	93.8	0.6602
Yes	2.8	1.0		7.0	6.2	
Arthritis: No	97.8	98.5	0.2957	97.9	97.6	0.7405
Yes	2.2	1.5		2.1	2.4	
Employment sector:						
Agriculture	2.2	4.2		1.0	7.5	
Private (non agricultural)	72.5	87.7	<0.0001	72.1	89.8	<0.0001
Public	25.3	8.1		26.9	2.7	
Repetitive movements:(2-4 /mn)						
No	89.8	68.8		78.2	38.4	
Yes, with breaks	8.3	25.2	<0.0001	18.3	37.4	<0.0001
Yes, without breaks	1.9	6.0		3.5	24.2	
Forceful movements:						
Never	76.3	4.1		82.8	61.3	
<2hrs/day	16.4	29.0	<0.0001	12.1	20.4	<0.0001
>=2 hrs/day	7.3	28.9		5.1	18.3	
Arm(s) above shoulder:						
Never	78.0	41.5		69.9	57.8	
<2hrs/d	16.4	37.4	<0.0001	20.3	22.5	<0.0001
>=2 hrs/d	5.6	21.1		9.8	19.7	
Hand behind trunk posture:						
Never	77.9	73.0		78.2	84.1	
<2hrs/d	18.3	20.8	0.0380	16.4	11.1	0.0803
>=2 hrs/d	3.8	6.2		5.4	4.8	
Arm(s) away from body:						
Never	79.2	47.9		76.7	61.9	
<2hrs/d	13.4	27.4	<0.0001	13.1	14.9	<0.0001
>=2 hrs/d	7.4	24.7		10.2	23.2	
Use of vibrating hand tools:						
<2hrs/day	84.5	49.5	<0.0001	95.5	81.6	<0.0001
>=2 hrs/day	15.5	50.5		4.5	18.4	
Wrist flexion:						
<2hrs/day	67.8	24.5	<0.0001	61.0	24.9	<0.0001
>=2 hrs/day	32.2	75.4		39.0	75.1	
Any of 6 principal upper limb disorders*	8.5	13.4	0.0028	12.0	23.9	<0.0001
Rotator cuff syndrome (ICD10 M75.1)	4.6	8.5	0.0021	7.0	14.5	0.0001
Carpal tunnel syndrome (ICD10 G56.0)	1.9	2.5	0.4138	3.0	6.5	0.0089

* Includes rotator cuff syndrome ICD10 M75.1, epicondylitis ICD10 M77.1, cubital tunnel syndrome ICD10 G56.2, extensor/flexor tendonitis/tenosynovitis ICD10 G65.8, de Quervain's disease ICD10 G65.4, carpal tunnel syndrome ICD10 G56.0.

Table 3. Occupational disparities in the risk of upper limb disorders in the Pays de la Loire study (age-adjusted Prevalence Ratios (PR), 95% Confidence Intervals (95% CI)).

Any of 6 principal upper limb disorders[*]					
		Men (n=1549; 175 cases)		Women (n=1107; 167 cases)	
		PR (95% CI)	*% excess risk*[†]	*PR (95% CI)*	*% excess risk*
Model 1[‡]	Nonmanual job	1.0		1.0	
	Manual job	1.70 (1.27-2.28)		1.89 (1.43.-2.49)	
Model 2[3]	Nonmanual job	1.0		1.0	
	Manual job	1.67 (1.24-2.24)	-	1.90 (1.44-2.51)	-
	BMI <30 kg/m²	1.0		1.0	
	BMI >=30 kg/m²	1.56 (1.07-2.27)		0.90 (0.57-1.42)	
	Diabetes : No	1.0		1.0	
	Yes	1.32 (0.62-2.82)		2.72 (1.34-5.52)	
	Thyroid disease: No	1.0		1.0	
	Yes	0.46 (0.10-2.11)		1.00 (0.62-1.63)	
	Arthritis: No	1.0		1.0	
	Yes	0.95 (0.27-3.33)		1.09 (0.55-2.14)	
Model 3[§]	Nonmanual job	1.0		1.0	
3[§]	Manual job	1.46 (1.08-1.97)	31	1.44 (1.07-1.94)	51
	No repetitive movements	1.0		1.0	
	Repetitive movements with breaks	1.72 (1.27-2.35)		1.76 (1.29-2.40)	
	Repetitive movements w/o breaks	1.98 (1.15-3.43)		2.25 (1.52-3.33)	
Model 4[4]	Nonmanual job	1.0		1.0	
	Manual job	1.48 (1.07-2.05)	28	1.83 (1.37-2.44)	8
	Force exertion: Never	1.0		1.0	
	<2hrs/d	1.16 (0.79-1.68)		1.28 (0.89-1.82)	
	>=2 hrs/d	1.53 (1.07-2.16)		1.13 (0.69-1.85)	
Model 5[4]	Nonmanual job	1.0		1.0	
	Manual job	1.32 (0.95-1.84)	52	1.39 (1.02-1.89)	57
	No repetitive movements	1.0		1.0	
	Repetitive movements with breaks	1.68 (1.22-2.30)		1.75 (1.27-2.39)	
	Repetitive movements w/o breaks	1.95 (1.12-3.38)		2.30 (1.55-3.42)	
	Forceful movements: Never	1.0		1.0	
	<2hrs/d	1.18 (0.82-1.70)		1.31 (0.91-1.87)	
	>=2 hrs/d	1.44 (1.00-2.06)		1.05 (0.65-1.71)	

[*] Includes rotator cuff syndrome ICD10 M75.1, epicondylitis ICD10 M77.1, cubital tunnel syndrome ICD10 G56.2, extensor/flexor tendonitis/tenosynovitis ICD10 G65.8, de Quervain's disease ICD10 G65.4 and carpal tunnel syndrome ICD10 G56.0.
[†] % change from Model 2
[‡] Adjusted for age
[§] Adjusted for age, obesity, diabetes, thyroid disease, arthritis

Table 4. Occupational disparities in the risk of rotator cuff syndrome (ICD10 M75.1) in the Pays de la Loire study (age-adjusted Prevalence Ratios (PR), 95% Confidence Intervals (95% CI)

Rotator cuff syndrome (ICD10 M75.1)					
		Men (n=1549, 105 cases)		Women (n=1107, 99 cases)	
		PR (95% CI)	*% excess risk*[*]	*PR (95% CI)*	*% excess risk*
Model 1[†]	Nonmanual job	1.0		1.0	
1[†]	Manual job	2.08 (1.39-3.10)		1.95 (1.34-2.83)	
Model 2[‡]	Nonmanual job	1.0		1.0	
2[‡]	Manual job	2.07 (1.38-3.08)		1.90 (1.31-2.77)	
	BMI <30 kg/m²	1.0		1.0	
	BMI >=30 kg/m²	1.42 (0.85-2.39)		1.01 (0.56-1.81)	
	Diabetes : No	1.0		1.0	
	Yes	1.42 (0.50-4.02)		1.77 (0.83-3.75)	
	Thyroid disease: No	1.0		1.0	
	Yes	0.80 (0.15-4.12)		0.82 (0.42-1.60)	
	Arthritis: No	1.0		1.0	
	Yes	0.91 (0.16-5.26)		2.35 (1.28-4.32)	
Model 3[3]	Nonmanual job	1.0		1.0	
	Manual job	1.72 (1.14-2.59)	33	1.40 (0.95-2.09)	56
	No repetitive movements	1.0		1.0	
	Repetitive movements with breaks	2.12 (1.43-3.15)		1.83 (1.21-2.74)	
	Repetitive movements w/o breaks	1.97 (0.93-4.17)		2.57 (1.50-4.41)	
Model 4[3]	Nonmanual job	1.0		1.0	
	Manual job	1.81 (1.16-2.82)	24	1.88 (1.26-2.80)	2
	Forceful movements: Never	1.0		1.0	
	<2hrs/d	1.09 (0.66-1.80)		1.11 (0.66-1.84)	
	>=2 hrs/d	1.65 (1.03-2.61)		1.03 (0.53-2.00)	
Model 5[3]	Nonmanual job	1.0		1.0	
	Manual job	1.67 (1.11-2.52)	37	1.77 (1.20-2.60)	14
	Arm(s) above shoulder: Never	1.0		1.0	
	<2hrs/d	1.06 (0.67-1.67)		1.21 (0.75-1.93)	
	>=2 hrs/d	2.57 (1.67-3.97)		1.75 (1.09-2.83)	
Model 6[3]	Nonmanual job	1.0		1.0	
	Manual job	2.06 (1.37-3.09)	<1	1.96 (1.39-2.85)	+6
	Hand behind trunk posture: Never	1.0		1.0	
	<2hrs/d	1.07 (0.68-1.68)		1.43 (0.88-2.32)	
	>=2 hrs/d	1.02 (0.44-2.36)		2.11 (1.13-3.93)	
Model 7[3]	Nonmanual job	1.0		1.0	
	Manual job	1.84 (1.21-2.81)	21	1.63 (1.09-2.43)	30
	Arm(s) away from the body: Never				
	<2hrs/d	1.0		1.0	
	>=2 hrs/d	1.49 (0.96-2.30)		1.23 (0.69-2.09)	
		1.42 (0.87-2.31)		2.13 (1.36-3.33)	
Model 8[§]	Nonmanual job	1.0	67	1.0	62
8[§]	Manual job	1.35 (0.86-2.12)		1.34 (0.88-2.03)	

[*] % change from Model 2
[†] Adjusted for age
[‡] Adjusted for age, obesity, diabetes, thyroid disease, arthritis
[§] Adjusted for age, obesity, diabetes, thyroid disease, arthritis, repetitive movements, force exertion, arm(s) above shoulder position, hand behind trunk posture, arm(s) away from body posture

Table 5. Occupational disparities in the risk of carpal tunnel syndrome (ICD10 G56.0) in the Pays de la Loire study (age-adjusted Prevalence Ratios (PR), 95% Confidence Intervals (95% CI))

Carpal tunnel syndrome (ICD10 G56.0)					
		Men (n=1549, 35 cases)		Women (n=1107, 44 cases)	
		PR (95% CI)	*% excess risk* [*]	*PR (95% CI)*	*% excess risk*
Model 1[†]	Nonmanual job Manual job	1.0 1.44 (0.73-2.85)		1.0 2.10 (1.17-3.75)	
Model 2[‡]	Nonmanual job Manual job BMI<30 kg/m² BMI >=30 kg/m² Diabetes : No Yes Thyroid disease: No Yes Arthritis: No Yes	1.0 1.40 (0.70-2.76) 1.0 1.83 (0.68-4.88) 1.0 1.10 (0.13-8.85) 0 exposed cases 1.0 2.06 (0.29-14.36)		1.0 2.10 (1.17-3.74) 1.0 1.06 (0.40-2.73) 1.0 2.52 (0.28-22.43) 1.0 0.57 (0.14-2.30) 0 exposed cases	-
Model 3[3]	Nonmanual job Manual job No repetitive movements Repetitive movements with breaks Repetitive movements w/o breaks	1.0 1.34 (0.67-2.68) 1.0 0.97 (0.39-2.44) 2.20 (0.64-7.60)	15	1.0 1.33 (0.65-2.72) 1.0 2.99 (1.45-6.18) 2.85 (1.08-7.52)	70
Model 4[3]	Nonmanual job Manual job Use of vibrating hand tools: <2hrs/day >=2 hrs/day	1.0 1.41 (0.67-2.96) 1.0 0.97 (0.39-2.37)	-	1.0 1.81 (1.01-3.26) 1.0 3.29 (1.49-7.28)	23
Model 5[3]	Nonmanual job Manual job Wrist flexion: <2hrs/day >=2 hrs/day	1.0 1.11 (0.49-2.54) 1.0 1.82 (0.83-3.98)	72	1.0 1.55 (0.84-2.87) 1.0 2.10 (1.11-3.97)	50
Model 8[§] 8[§]	Nonmanual job Manual job	1.0 1.12 (0.49-2.56)	70	1.0 1.04 (0.51-2.11)	96

[*] % change from Model 2
[†] Adjusted for age
[‡] Adjusted for age, obesity, diabetes, thyroid disease, arthritis
[§] Adjusted for age, obesity, diabetes, thyroid disease, arthritis, repetitive movements, force exertion, arm(s) above shoulder position, hand behind trunk posture, arm(s) away from body posture

Table 6. Predicted effect of a decrease in levels of physical work exposures[*] on the number of cases of upper limb disorders[†] among manual workers (871 men and 289 women).

	MEN		WOMEN	
	N cases	**% preventable**	**N cases**	**% preventable**
Expected in the study population	115.1	-	69.6	-
Decrease in exposure to repetitive movements (from level 2 to level 1)	114.6	<1	67.6	2.9
Decrease in exposure to forceful movements (from level 2 to level 1)	108.0	6.1	69.8	+ <1.0
Decrease in exposure to both repetitive and forceful movements (from level 2 to level 1)	108.22	6.0	69.9	+ <1.0
No forceful movements (level 0)	100.6	12.6	71.6	+2.8
Decrease in exposure to repetitive movements (from level 2 to level 1) + no forceful movements (level 0)	100.5	12.7	70.0	+ <1.0
No repetitive movements (level 0)	97.7	15.0	46.7	32.8
No repetitive movements (level 0) + decrease in exposure to forceful movements (from level 2 to level 1)	90.8	21.0	48.5	30.3
No repetitive or forceful movements (level 0)	87.6	23.8	47.7	31.4

[*] Repetitive movements : level 0 = no exposure, level 1=exposure, with an hourly 10 minute break; level 2= exposure, without an hourly 10 minute break; forceful movements: level 0= no exposure; level 1= <2hrs/day; level 2= >=2hrs/day

[†] Includes rotator cuff syndrome ICD10 M75.1, epicondylitis ICD10 M77.1, cubital tunnel syndrome ICD10 G56.2, extensor/flexor tendonitis/tenosynovitis ICD10 G65.8, de Quervain's disease ICD10 G65.4, carpal tunnel syndrome ICD10 G56.0.